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Transient overvoltage protection

to IET Wiring Regulations 17th Edition (BS 7671:2008+A1:2011)

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The latest amendment to the IET Wiring Regulations 17th Edition (BS 7671) brings into sharp focus the need to protect sensitive and critical electronic systems against transient overvoltages (surges).

Amendment 1 of BS 7671, effective from 1st January 2012, requires all electrical system designs and installations to be assessed against risk of transient overvoltages of atmospheric origin, or from switching events, in line with its Sections 443 & 534.

Section 443 defines the criteria for risk assessment, whereas Section 534 describes the selection and installation of suitable Surge Protective Devices (SPDs), where required, for effective transient overvoltage protection.

Whilst concerned with protection of AC power supplies, BS 7671 does make clear the need to protect all incoming/outgoing metallic service lines, including data, signal and telecoms lines, following BS EN 62305.

Why is transient overvoltage protection so important?

Transient overvoltages are short duration surges in voltage between two or more conductors (L-PE, L-N or N-PE), which can reach up to 6 kV on 230 Vac power lines, and generally result from:

- Atmospheric origin (lightning activity) through resistive or inductive coupling *(see Figures 1 & 2),* and/or
- Electrical switching of inductive loads

Transient overvoltages significantly damage and degrade electronic systems.

Outright damage to sensitive electronic systems, such as computers etc, occurs when transient overvoltages between L-PE or N-PE exceed the withstand voltage of the electrical equipment (i.e. above 1.5 kV for Category I equipment to BS 7671 Tables 44.3 & 44.4).

Equipment damage leads to unexpected failures and expensive downtime, or risk of fire/electric shock due to flashover, if insulation breaks down.

Degradation of electronic systems, however, begins at much lower overvoltage levels and can cause data losses, intermittent outages and shorter equipment lifetimes *(see Figure 3).*

Where continuous operation of electronic systems is critical, for example in hospitals, banking and most public services, degradation must be avoided by ensuring these transient overvoltages, which occur between L-N, are limited below the impulse immunity of equipment. This can be calculated as twice the peak operating voltage of the electrical system, if unknown (i.e. approximately 715 V for 230 V systems).

Protection against transient overvoltages can be achieved through installation of a coordinated set of SPDs at appropriate points in the electrical system, in line with BS 7671 Section 534 and the guidance provided in this publication.

Selecting SPDs with lower (i.e. better) voltage protection levels (U_p) is a critical factor, especially where continuous usage of electronic equipment is essential.

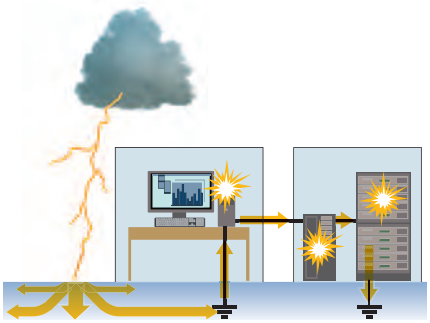


Figure 1: Resistive coupling

Resistively coupled transients are caused by differences in potential between two connected earths.

Energy from ground strikes flows away through the path of least resistance, and increases the potential in local earths, cabling and electronic circuitry.

Where these are linked to separate earths by a metallic service line, the potential is shared, creating transient overvoltages as the current attempts to flow.

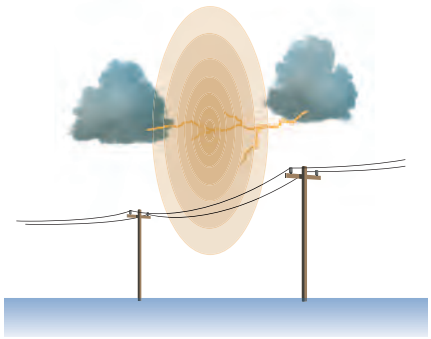


Figure 2: Inductive coupling

Inductively coupled transients are caused by electromagnetic pick-up.

A lightning discharge gives rise to an electromagnetic field. If metallic services, such as overhead power lines, pass through this field a voltage will be picked up by, or induced on to, the line.

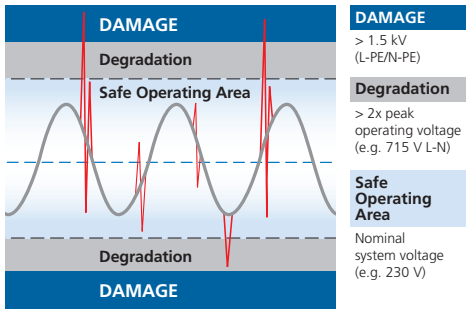


Figure 3: Equipment risk

Degradation of electronic systems begins at lower transient overvoltage levels and affects critical electronic systems whenever the impulse immunity of the equipment is compromised.

Damage occurs when a transient overvoltage exceeds the withstand voltage of electrical and electronic equipment.

Transient overvoltage risk assessment

Sections 443 and 534 of BS 7671 cover transient overvoltage risk and SPD selection/installation on AC power supplies.

Determining risk to BS 7671

BS 7671 Section 443 establishes that protection against transient overvoltages is required in an installation which includes a structural lightning protection system (LPS), and/or connected metallic service lines at risk from lightning.

It details protection requirements for AC power lines, and refers to BS EN 62305 regarding additional metallic service lines (data, signal & telecoms).

Protection is required where:

- The expected transient overvoltages would exceed the withstand voltage[1] of installed equipment (as defined by Tables 44.3 & 44.4 of BS 7671), and
- The risk of consequential loss (to life, property or provision of service) is deemed unacceptable (443.2.4)

If terminal equipment to Category I of Table 44.3, such as computers/laptops etc., is to be connected to the fixed electrical installation, it must be protected against transient overvoltages (Table 44.4).

The flowchart below *(Figure 4)* defines risk assessment in terms of potential consequential losses.

Note, as per the flowchart, risk of consequential loss to human life, public services or to commercial/industrial activity **always** results in the need to install protection measures (443.2.4 Note 2).

Following this process, where the need for protection is established, BS 7671 requires the selection and installation of SPDs on the AC power supply in accordance with its Section 534.

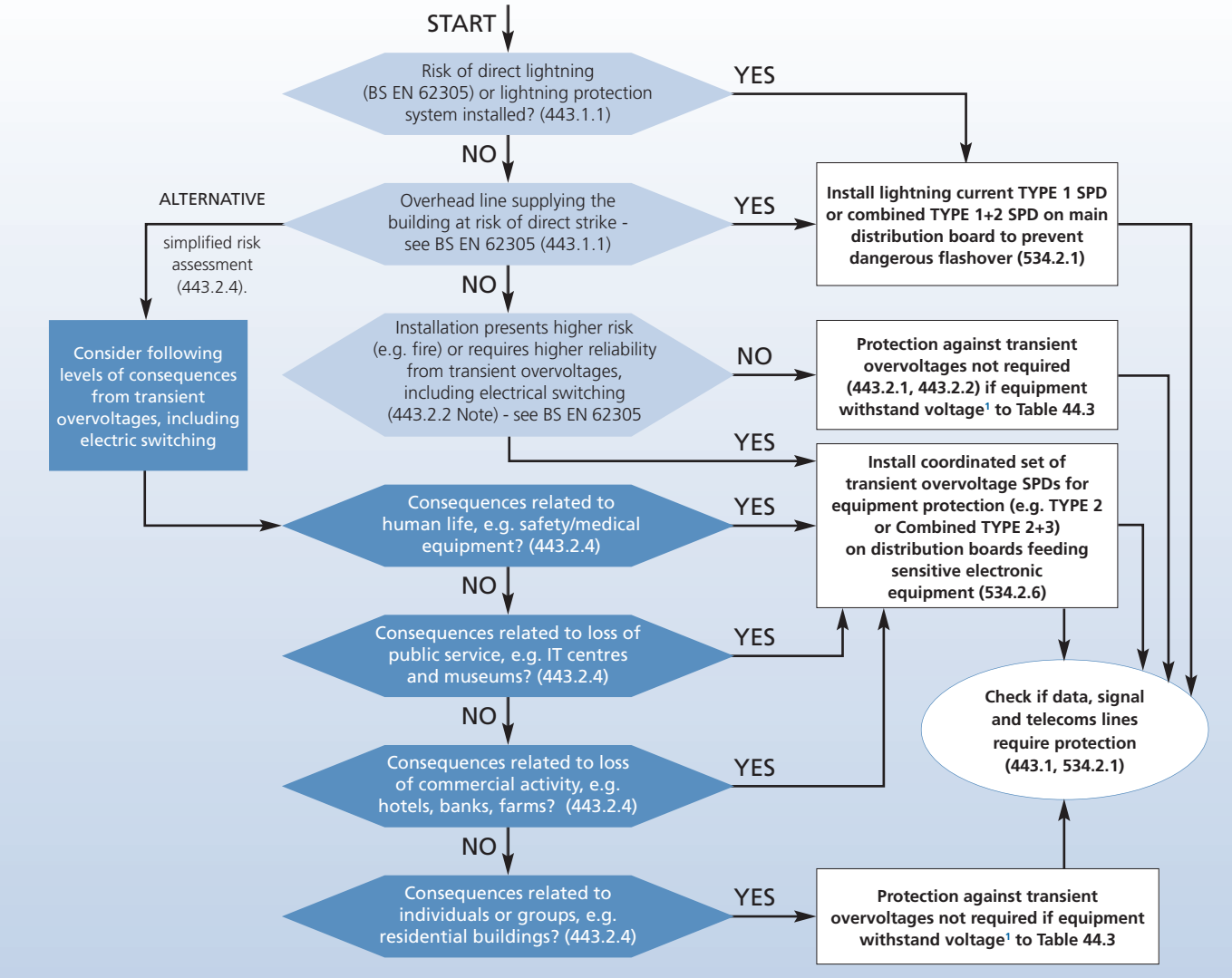


Figure 4: Transient overvoltage risk assessment to BS 7671

[1] Note, withstand voltage protects only against failure of equipment. For continuous operation of critical equipment, impulse immunity must be protected.

SPD selection & installation

Assessing installation requirements

BS 7671 Section 534 focuses guidance on selection and installation of SPDs to limit transient overvoltages on the AC power supply.

Section 443 states that 'transient overvoltages transmitted by the supply distribution system are not significantly attenuated downstream in most installations' (443.1.1 NOTE 3).

BS 7671 Section 534 therefore recommends that SPDs are installed at key locations in the electrical system:

- As close as practicable to the origin of the installation (usually in the main distribution board after the meter) (534.2.1)
- As close as practicable to sensitive equipment (sub-distribution level), and local to critical equipment (534.2.1)

Figure 5 shows a typical installation on a 230/400 V TN-C-S/TN-S system using Furse SPDs, to meet the requirements of BS 7671.

The illustration demonstrates how effective protection comprises a service entrance SPD to divert high energy lightning currents to earth, followed by downstream SPDs at appropriate points to protect sensitive and critical equipment.

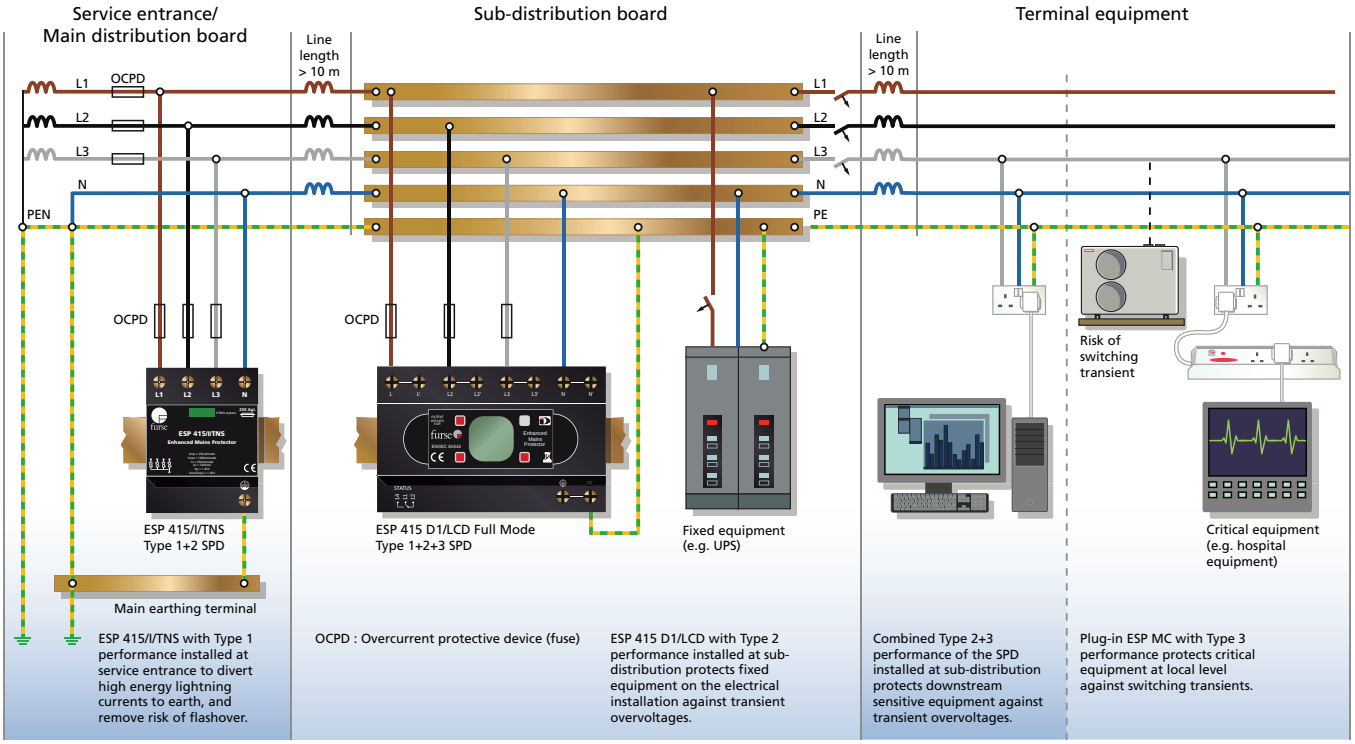


Figure 5: Typical installation on a 230/400 V TN-C-S/TN-S system using Furse SPDs, to meet the requirements of BS 7671

Selecting appropriate SPDs

SPDs are classified by Type within BS 7671 (534.2.1), following the criteria established in BS EN/IEC 62305.

Where a building includes a structural LPS, or connected overhead metallic services at risk from a direct lightning strike, equipotential bonding SPDs (Type 1 or Combined Type 1+2) must be installed at the service entrance, to remove risk of flashover (534.2.3.4.2).

Installation of Type 1 SPDs alone however does not provide protection to electronic systems (534.2.1 NOTE 3).

Transient overvoltage SPDs (Type 2 and Type 3, or Combined Type 1+2+3 and Type 2+3) should therefore be installed downstream of the service entrance.

These SPDs further protect against those transient overvoltages caused by indirect lightning (via resistive or inductive coupling) and electrical switching of inductive loads.

Combined Type SPDs (such as the Furse ESP D1 Series and ESP M1/M2/M4 Series) significantly simplify the SPD selection process, whether installing at the service entrance or downstream in the electrical system.

These SPDs, classed as enhanced SPDs to BS EN 62305, offer technical and economic advantages over standard SPDs, providing:

- Combined equipotential bonding and transient overvoltage protection (Type 1+2 & Type 1+2+3)
- Full mode (common and differential mode) protection, essential to safeguard sensitive electronic equipment from all types of transient overvoltage - lightning & switching (524.2.2 NOTE 1), and
- Effective SPD coordination within a single unit versus installation of multiple standard Type SPDs to protect terminal equipment

SPD performance

The most important parameter for SPD performance is its voltage protection level (U_p) (534.2.3.1.1) and not its energy withstand (e.g. I_{imp}) (Fig 16A.5).

The lower the voltage protection level (U_p), the better the protection afforded to the withstand voltage or impulse immunity of the equipment (534.2.3.1.1).

Equally, short connecting leads between the SPD and conductors are paramount to keep transient overvoltages to a minimum *(see Figure 6)*.

Controlled installation to BS 7671 of SPDs with lower (better) voltage protection levels (U_p), and short connecting leads optimises protection at terminal equipment by:

- Limiting additive inductive voltages on the SPD's connecting leads
- Reducing risk of downstream voltage oscillations which can reach up to twice the SPD's U_p and cause damage at equipment (534.2.3.1.2)

Furse SPDs are designed with industry leading low voltage protection levels (U_p), and many include a remote display option to ensure SPD positioning as close as possible to conductors.

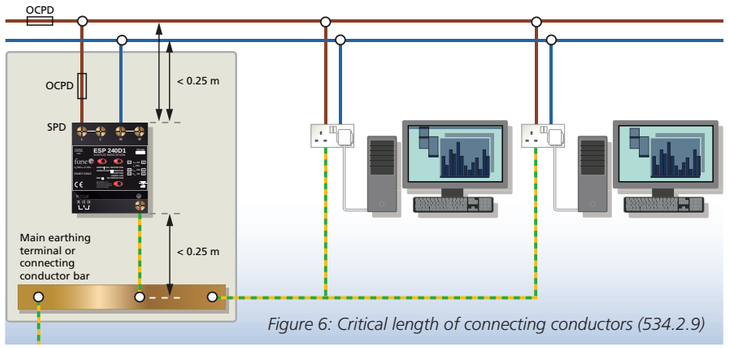


Figure 6: Critical length of connecting conductors (534.2.9)

SPD connections should be kept as short as possible ideally below 0.25 m between SPD, live conductors & earth, but in any case not more than 0.5 m, to reduce risk of additive inductive voltage drops across the conductors.

SPD coordination

Smaller installations may require only a single SPD (534.2.2).

However where the protective distance between SPD and electrical equipment exceeds 10 m, additional downstream SPDs may be needed to counter voltage oscillations (534.2.3.1.1).

SPDs installed on the same conductor should coordinate with each other to ensure effective, continuous protection (534.2.1 & 534.2.3.6).

The selection chart *(right)* defines the appropriate Furse SPDs to achieve coordination on a 230/400 V TN-S or TN-C-S system, dependent on installation requirement, in line with BS 7671. For TT systems, contact Furse.

All Furse SPD sets for power and data lines are specifically designed to ensure coordination.

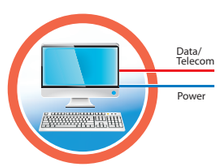
Following BS 7671, installation of Furse SPDs at service entrance, sub-distribution and at critical electrical equipment, will ensure optimal, consistent protection against transient overvoltages.

Protect additional metallic services

BS 7671 is focused towards protection of AC power supplies.

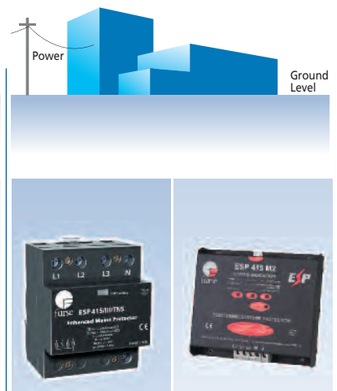
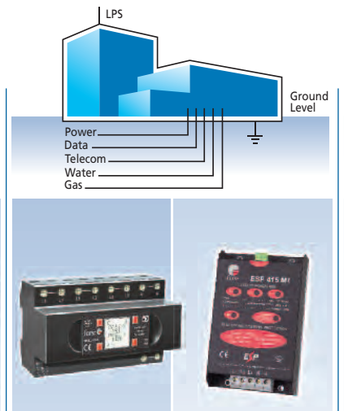
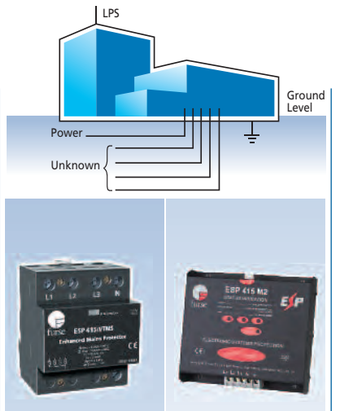
For protection measures against direct lightning strikes, and against transient overvoltages on additional metallic service lines (e.g. data, signal & telecoms), BS 7671 refers to BS EN 62305 (534.1 NOTE 2).

Full protection of electronic systems can only be achieved if all incoming/outgoing metallic services, including data, signal and telecoms lines are protected.



IMPORTANT: Equipment is **ONLY** protected against transient overvoltages if all incoming / outgoing mains and data lines have protection fitted.

Protection for 230/400 V TN-S or TN-C-S supplies

	■ No external lightning protection system fitted ■ Underground mains supply feed	■ No external lightning protection system fitted ■ Exposed overhead mains supply feed	■ External lightning protection system fitted ■ Multiple connected metallic services	■ External lightning protection system fitted ■ No. of services unknown
3 Phase 400 V Service entrance, after electricity meter (Main distribution board (MDB)	 **ESP 415 D1 Series** or **ESP 415 M1 Series**	 **ESP 415/III/TNS** or **ESP 415 M2 Series (for electronics located near MDB before SDB)**	 **ESP 415 D1 Series** or **ESP 415 M1 Series**	 **For LPL I & II ESP 415/I/TNS or ESP 415 M4 (for electronics located near MDB before SDB)** or **For LPL III & IV ESP 415/III/TNS or ESP 415 M2 (for electronics located near MDB before SDB)**
3 Phase 400 V 1 Phase 230 V Sub-distribution board (SDB) - located > 10 m from MDB feeding electronic equipment	 or  **For 3 Phase 400 V: ESP 415 D1 Series, or ESP 415 M1 Series**		 or  **For 1 Phase 230 V: ESP 240 D1 Series, or ESP 240 M1 Series**	
Critical terminal equipment - located > 10 m from SDB	 **ESP MC** **ESP MC/TN/RJ11 (e.g. for fax machines)** **ESP MC/Cat-5e (e.g. for servers)**			

Standard Part No.	Remote Display Option Part No.[1]	Weatherproof enclosure[2]	SPD Performance	Status indication
ESP 415/I/TNS	-	WBX D4	Combined Type 1+2	LED
ESP 415/III/TNS	-	WBX D4	Combined Type 1+2	LED
ESP 415 M4	ESP 415 M4R	WBX M4	Combined Type 1+2+3	LED
ESP 415 M2	ESP 415 M2R	WBX M2	Combined Type 1+2+3	LED
ESP 415 D1	ESP 415 D1R	WBX D8	Combined Type 1+2+3	LED
ESP 415 D1/LCD	ESP 415 D1R/LCD	WBX D8	Combined Type 1+2+3	LCD[3]
ESP 415 M1	ESP 415 M1R	WBX 4	Combined Type 1+2+3	LED
ESP 240 D1	-	WBX D4	Combined Type 1+2+3	LED
ESP 240 M1	-	WBX 3	Combined Type 1+2+3	LED
ESP MC	-	-	Combined Type 2+3	LED

[1] Remote displays enable positioning of an SPD close to conductors with the display mounted in an easily visible position.

[2] Weatherproof enclosures are rated to IP65 or above and enable mounting of SPDs in adverse environments. They should be used where the SPD is not mounted within a distribution board.

[3] LCD remote display includes rotating screen text (by 90°) for optimal positioning and viewing, as well as audible status warning.

SPD selection notes

- LPL refers to Lightning Protection Level, as defined by BS EN/IEC 62305.
- Voltage protection level (U_p) at the equipment terminals should be lower than the withstand voltage of sensitive equipment (1.5 kV Category I) or the impulse immunity of critical equipment (approx. 715 V for 230/400 V supplies) (534.2.3.1).
- Type 3 SPD performance applies at equipment terminals. To BS EN 62305 an SPD's voltage protection level (U_p) should be no more than 600 V when tested to BS EN 61643-11 Class III test. All the Furse Combined Type 1+2+3 & Type 2+3 SPDs shown in the selection chart meet this requirement.
- All Furse SPDs shown have been tested to at least the minimum nominal discharge current (I_{nspd}) of 5 kA 8/20 waveform, for TN-S or TN-C-S supplies as specified by BS 7671 (534.2.3.4.1). Note: I_{nspd} as defined by BS 7671 correlates with I_n of BS EN/IEC 61643.
- Where a service entrance Type 1 SPD is required, it should be tested to withstand lightning impulse currents (I_{imp}) to BS EN/IEC 61643.
- The value of I_{imp} for an installation should be calculated according to BS EN 62305. Where it cannot be calculated, the SPD should have capability not less than 12.5 kA per mode to PE or common mode (534.2.3.4.2).

For more information on SPD selection, contact Furse.

Transient overvoltage (surge) protection

Amendment 1 of BS 7671 places a clear responsibility for transient overvoltage protection on electrical system designers and installers.

For many in this sphere of work, assessing the need for transient overvoltage protection will be a new requirement.

Defining when and where to install SPDs can be a complex process, and sourcing the right expertise can often be as important as specifying the right product.

That's why we support our transient overvoltage solutions with CPD-accredited seminars and training, including:

- **Transient overvoltage protection to BS 7671**

  Providing key guidance on the risk assessment principles defined within Section 443, plus selection and installation of SPDs in line with Section 534 of BS 7671:2008 (+A1:2011).

- **Transient overvoltage protection to BS EN 62305**

  Detailing the protection requirements for electrical and electronic systems within structures, in accordance with BS EN 62305-4, including the lightning protection zone (LPZ) concept, and the application and coordination of SPDs.

Seminars are conducted at customer premises or at our head office in Nottingham, UK.

To arrange a seminar, or for more information on protecting your installations against transient overvoltages, contact us directly on:

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